We claim:

1.   An apparatus for trapping small particles by forming optical traps, comprising:

a first phase patterning optical element for receiving a laser beam and to impart a selected cross section to the wavefront of the laser beam;

a second phase patterning optical element downstream from the first phase patterning optical element for receiving a laser beam and forming at least two beamlets; and,

a focusing lens with a front and a back aperture disposed downstream from the second phase patterning optical element; whereby the second phase patterning optical element in cooperation with the focusing lens can separately converge beamlets and establish the gradient conditions to form optical traps capable of manipulating small particles.

2.   The apparatus of claim 1 wherein the first phase patterning optical element, is selected from the group consisting of transmissive and reflective.

3.   The apparatus of claim 2 wherein the first phase patterning optical element, is selected from the group consisting of static and dynamic.

4.   The apparatus of claim 3 wherein the first phase patterning optical element is selected from the group consisting of gratings, diffraction gratings, reflective gratings, transmissive gratings, holograms, stencils, light shaping holographic filters, polychromatic holograms, lenses, mirrors, prisms, and waveplates.

5.   The apparatus of claim 3 wherein the first phase patterning optical element is selected from the group consisting of variable computer generated diffractive patterns, variable phase shifting materials, variable liquid crystal phase shifting arrays, micro-mirror arrays, piston mode micro-mirror arrays, spatial light modulators, electro-optic deflectors, accousto-optic modulators, deformable mirrors, and reflective MEMS arrays.

6.   The apparatus of claim 1 wherein the first and second phase patterning optical elements are selected from the group consisting of transmissive and reflective.

7.   The apparatus of claim 1 wherein the first and second phase patterning optical elements are selected from the group consisting of static and dynamic.

8.   he apparatus of claim 7 wherein at least one of the first and second phase patterning optical elements is selected from the group consisting of gratings, diffraction gratings, reflective gratings, transmissive gratings, holograms, stencils, light shaping holographic filters, polychromatic holograms, lenses, mirrors, prisms, and waveplates.

9.   he apparatus of claim 7 wherein at least one first phase patterning optical element, is dynamic and selected from the group consisting of variable computer generated diffractive patterns, variable phase shifting materials, variable liquid crystal phase shifting arrays, micro-mirror arrays, piston mode micro-mirror arrays, spatial light modulators, electro-optic deflectors, accousto-optic modulators, deformable mirrors, and reflective MEMS arrays.

10.   The apparatus of claim 3 wherein the first phase patterning optical element is a phase-only spatial light modulator.

11.   The apparatus of claim 7 wherein at least on of the first and second phase patterning optical element is a phase-only spatial light modulator.

12.   The apparatus of claim 1 further comprising a means for generating a laser beam.

13.   The apparatus of claim 12 wherein the means for generating the laser beam is selected from the group consisting of solid state lasers, diode pumped lasers, gas lasers, dye lasers, alexanderite lasers, free electron lasers, VCSEL lasers, diode lasers, Ti- Sapphire lasers, doped YAG lasers, doped YLF lasers, diode pumped YAG lasers, and flash lamp-pumped YAG lasers.

14.   The apparatus of claim 1 wherein said focusing lens is an objective lens.

15.   The apparatus of claim 1 further comprising a beam splitter disposed opposite the back aperture of the focusing lens, whereby beamlets can be directed at the back aperture and

an optical data stream can pass along the optical axis of the focusing lens from front to back aperture.

16.   The apparatus of claim 15 further comprising an optical filter selected from the group consisting of polarizing and band pass disposed along the optical axis of the focusing lens and behind the beam splitter.

17.   The apparatus of claim 1 further comprising at least one telescope lens system disposed between upstream from the focusing lens and downstream from the second phase patterning optical element

18.   The apparatus of claim 15 further comprising at least one telescope lens system disposed upstream from the beam splitter.

19.   The apparatus of claim 15 further comprising at least one telescope lens system disposed downstream from the beam splitter.

20.   The apparatus of claim 15 further comprising at least one telescope lens system disposed upstream and downstream from the beam splitter.

21.   The apparatus of claim 1 wherein the selected cross section is substantially square.

22.   The apparatus of claim 1 wherein the selected cross section is intense at its periphery.

23.   A system for trapping small particles by forming movable optical traps, comprising:
        a phase patterning optical element for receiving a laser beam and to impart a square cross section to the wavefront of the laser beam;
        at least one computer;
        a dynamic phase patterning optical element with a variable surface encoded, by the computer, with a hologram for receiving a laser beam from the phase patterning optical element; whereby movable beamlets can be formed from a received laser beam; and,
        an objective lens with a front and a back aperture disposed downstream from the dynamic phase patterning optical element; whereby the dynamic phase patterning optical

element in cooperation with the objective lens can separately converge beamlets and establish the gradient conditions to form optical traps capable of manipulating small particles.

24.   The system of claim 23 further comprising a means for generating a laser beam.

25.   The system of claim 23 further comprising a beam splitter disposed oposite the back aperture of the objective lens, whereby beamlets can be directed at the back aperture and an optical data stream can pass along the optical axis of the focusing lens from front to back aperture.

26.   The system of claim 23 further comprising a means for converting the optical data stream to a digital data stream adapted for use by a computer.

27.   The system of claim 23 further comprising at least one telescope lens system disposed upstream from the objective lens.

28.   The system of claim 25 further comprising at least one telescope lens system disposed upstream from the beam splitter.

29.   The system of claim 25 further comprising at least one telescope lens system disposed downstream from the beam splitter.

30.   The system of claim 25 further comprising at least one telescope lens system disposed upstream and downstream from the beam splitter.

31.   The system of claim 26 further comprising an Illumination source.

32.   The system of claim 23 wherein the selected cross section is substantially square.

33.   The system of claim 23 wherein the selected cross section is intense at its periphery.

34.   A method for trapping small particles, comprising :

generating a modified laser beam by imparting a square cross section to the wavefront of a laser beam direct at a first phase patterning optical element;

generating at least two beamlets by directing the modified laser beam at a second phase patterning optical element;

5   generating optical traps with a vessel by directing the laser beam through a focusing lens;

providing at least two small particles; and

containing the small particles in the optical traps.

10   35.   The method of claim 34 wherein the selected cross section is square.

36.   The method of claim 35 wherein the selected cross section has the most intensity at its periphery.

15   37.   A method for manipulating small particles with optical traps, comprising:

generating a modified laser beam by imparting a selected cross section to the wavefront of a laser beam direct at a first phase patterning optical element;

generating at least two beamlets by directing the modified laser beam at a second phase patterning optical element;

20   generating optical traps within a vessel by directing the beamlets through a focusing lens;

providing at least two small particles within the vessel; and

containing at least one small particle within an optical trap.

25   38.   The method of claim 37, further comprising altering the position of at least one optical trap.

39.   The method of claim 37, wherein the optical traps are formed of two or more of optical tweezers, optical vortices, optical bottles, optical rotators, or light cages.

30   40.   The method of claim 37 wherein the selected cross section is square.

41.   The method of claim 37 wherein the selected cross section has the most intensity at its periphery.

42.   The method of claim 37, wherein each optical trap is independently movable.

43.   The method of claim 37, wherein the movement of each optical trap is controlled by a

5   computer.

44.   The method of claim 37, wherein the movement of each optical trap is controlled by a

computer.

10   45.   A method for manipulating small particles with optical traps, comprising:

         generating a modified laser beam by imparting a selected cross section to the

wavefront of a laser beam direct at a first phase patterning optical element;

         generating at least two beamlets by directing the modified laser beam at a second

phase patterning optical element;

15   providing an optical data stream;

         generating optical traps within a vessel by directing the beamlets through a focusing

lens;

         providing at least two small particles within the vessel; and

         containing at least one small particle within an optical trap.

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46.   The method of claim 45 wherein the movement of each optical trap is controlled by a

computer.

47.   The method of claim 45, further comprising receiving the optical data-stream with a

25   computer.

48.   The method of claim 45, further comprising analyzing the optical data stream with the

computer.

30   49.   The method of claim 46, wherein the computer directs the movement of at least one

optical trap based on the analysis of the optical data stream.

50.   The method of claim 45, further comprising converting the optical data-stream to a video signal.

51.   The method of claim 50, further comprising receiving the video signal with a

5   computer.

52.   The method of claim 51, further comprising analyzing the video signal with the computer.

10 53.   The method of claim 51, further comprising using the computer to direct the movement of one or more optical traps based on the analysis of the video signal.

54.   The method of claim 50, wherein the video signal is used to produce an image.

15 55.   The method of claim 54, further comprising an operator viewing the image and directing the movement of one or more optical traps based on the viewing of the image.

56.   The method of claim 45, wherein the optical data stream is spectroscopic data.

20 57.   The method of claim 56, further comprising using a computer to direct the movement of one or more optical traps based on an analysis of the spectroscopic data.

58.   The method of claim 45, wherein the optical traps are formed of two or more of optical tweezers, optical vortices, optical bottles, optical rotators, or light cages.

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59.   The system of claim 45 wherein the selected cross section is intense at its periphery.

60.   The method of claim 36 wherein the selected cross section has the most intensity at its periphery.